ON THE ANATOMY OF ANCYLUS FLUVIATILIS O. F. Müller AND ANCYLUS LACUSTRIS Geoffroy.

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This paper first was written in German, and served as an inaugural dissertation for the Philosophical faculty at the University of Würzburg, in Bavaria. In rewriting it I have merely omitted a few unimportant details, and made one or two slight changes.

INTRODUCTION.

The position of these little animals in the system of classification was long a subject of dispute. At first they were placed by Linnæus[1] in the genus *Patella*, but in the same year (1767) Geoffroy[2] formed an especial genus for them, which he called *Ancylus*, on account of the resemblance of the shell to a Phygean cap (Ἀγχύλος).

The specimens of *fluviatilis*, which I had for examination, were obtained in the Main near Würzburg, and in a branch of the same near Gemünden—the only place in which the other species could be had was in a small pond near Aschaffenburg.

The work was carried on in the laboratory of Prof. C. Semper, at Würzburg, and I here take the opportunity of expressing my sincere thanks to him for his kindly advice and assistance.

Ferussac placed this genus, in 1837, among the Pulmonata, to which order it undoubtedly belongs.

Moquin-Tandon[3] believed that *Ancylus* was amphibian in its habits. I do not believe that the animal under natural and healthy conditions ever approaches the surface of the water. He says: " Does the animal breathe free air or that air dissolved in water ?" Ferussac[4] said positively that the animal was compelled to come to the surface to breathe. L. Agassiz,[5] Depuy, and others, were of the same opinion. To prove this, Moquin-Tandon[6] made the following experiments :—

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[1] Linnæus, Syst. Nat., 1767.

[2] Geoffroy, Trait. somm. d. Coquil fluv. et terres., etc., Paris, 1767.

[3] Moquin-Tandon, Recher. anatomico-physiol. sur l'Ancyle fluviatile (*Ancylus fluviatilis*), Journal de Conchyliologie, Tome iii, 1852, p. 124.

[4] Ferussac, Dict. class. d. Hist. Nat., Tome i, 1822.

[5] L. Agassiz, Act. Helvit., 1841.

[6] Recher. anat. physiol. s. l'Ancyle, etc., pp. 124-126.

Many animals were placed in a vessel of water, and the following facts were observed :

1. That not all the animals found the need of coming to the surface to breathe, and that many stayed at the bottom of the vessel.

2. That the need of air did not seem very strong, as they came slowly to the surface.

3. That certain individuals remained in the upper portion of the fluid.

4. That many went only partially out of the water.

5. That others left the water entirely, but remained in the neighborhood of it.

These and other facts show that they breathe air and are not water animals.   Further on he says :—

1. Seven animals were placed in tall champagne-glasses, which were filled with water; in the middle of the glass was placed a partition, so that the animals could not come to the surface; the water, however, could freely circulate.   The animals lived three days, at which time they were taken out.

2. Three individuals were placed in 45 cu. mm. of well-water, and these lived only eight hours.

3. Six *Ancyli* were placed for three days in 25, 30 and 50 cu. mm. of river-water; all remained living and some deposited eggs.

This last experiment seems to prove that they are not amphibious.

I made essentially the same experiments with the same results, and further found that when the *Ancyli* were placed in aquaria, in which there was running water, they never came to the surface; if, however, the water was not fresh, they would invariably come to the surface of the water.   I think, therefore, that the apparent amphibian habits are due to the fact that the water was not sufficiently aërated.   Probably the cause of such rapid death in the case of the animals that were placed in the well-water, was the presence in it of such a small percentage of air.

I will first take up the anatomy of both species in general, and describe the differences between them, and then consider the special part, which consists in :—

1. Formation of the radula.

2. Observations on the nervous system.

3. The anatomy of the excretory organ.

GENERAL ANATOMY.

In the following description I will first consider the anatomy of *A. fluviatilis* as a basis, for the anatomy of this is tolerably well known from the papers of Carl Vogt [1] and Moquin-Tandon.[2]   The first paper is short and incomplete, containing at the same time many mistakes, while the latter, unfortunately, is without plates. On *A. lacustris* no paper has as yet appeared, as far as I know.

The shell of *A. fluviatilis* is much larger than that of *A. lacustris*. In both species the form is that of a depressed cone and of a dirty brown color. In *A. fluviatilis* it is said [3] that the shell is wound to the left. I have never as yet seen a shell of *A. fluviatilis* which was in the least unsymmetrical, for the apex of all the specimens that I have examined lay in the median line, only rolled a little backwards.

In *A. lacustris*, however, the apex of the shell is wound slightly to the right, and this character has been considered sufficient to place this form in a separate genus, that of *Acroloxus* (Beck, 1837), or *Vellitia* (Gray, 1840), which, however, is not generally accepted.

The opening of the shell (*apertura*) is oval in both species; in *A. lacustris*, however, it is a much longer oval than in *A. fluviatilis*.

The shell contains such a quantity of conchyolin, that if it be thrown into an acid and left there until all the carbonate of lime be dissolved away, the organic framework of conchyolin remains perfect and the form unchanged.

If a piece of this be placed under the microscope a large number of the siliceous cases of diatomes are seen.   This is easily explained : the diatomes are found in large quantities on the objects on which the *Ancyli* are found, and as they are so small, they can easily pass between the mantle and the shell and then become covered by a layer of mother-of-pearl or nacre which is secreted by the external surface of the mantle and by which the shell grows in thickness.   This process of imbedding diatomes in nature is similar to that effected artificially by the Chinese, when they place their little leaden images between the mantle and the

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[1] Bemerkungen über den Bau der *Ancylus fluviatilis*.   Archiv für Anat. und Physiol. (Müller), 1841.

[2] Recher. anat. physiol. s. l'Ancyle, etc.

[3] C. Claus, Grundzüge d. Zoologie, Marburg, 1880–82, and others.

shells of bivalves, and allow them to become coated with mother-of-pearl.[1]

The mantle.—If the shell be carefully removed from the animal, the form of the body is found to be like that of the shell, namely, a depressed cone, and covered with a thin white membrane, the mantle. The base of the mantle, or that part which comes in contact with the aperture of the shell, is thickened and separated from the body, so that a deep groove is found running around the foot bounded externally by the internal surface of the mantle. The deepest point of this groove is at that point where the mantle and foot join. From this point, or the base of the groove (looking at the animal from below), hangs the gill, between the foot and the mantle, on the left side in *A. fluviatilis*, and on the right in *A. lacustris*. The inferior portion of the external surface of the mantle has a deposit of black pigment; this band of black pigment is not present in *A. lacustris*.

Organ of locomotion.—The only organ of locomotion is the foot, which is an oval muscular disk. The shape is like that of the aperture of the shell to which it belongs. The foot is formed of muscular fibres which run in four different directions, and between which the lacunæ or blood-spaces are found. One system of muscular fibres passes from before backward (longitudinal fibres); another, perpendicular to these, passes from side to side (transverse fibres). The other two systems are continuations of the muscle that binds the body to the shell. These latter fibres pass perpendicularly from the shell, and entering the foot, spread out fan-like into it, so that some of the fibres are almost horizontal and others almost perpendicular to the sole of the foot; these may be called lateral fibres. The animal holds itself to objects on which it creeps, by the foot, which acts like a sucker. If the animal be disturbed it draws the shell tightly downwards so that the soft parts are completely covered by the shell and thus protected. The movement of *Ancylus* is very slow. It never swims, as does, for example, *Limnæus*, on the surface of the water, as Gray and

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[1] An interesting account of this process may be found in F. Hague, Ueber d. natürliche u. künstliche Bildung der Perlen; and C. Th. von Siebold, Ueber d. Perlenbildung chinesischer Süsswasser-Muscheln, als Zusatz z. d. vorhergehenden Aufsatz. Zeitschr. f. wiss. Zool., Bd. viii, 1857.

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Turton [1] observed.   Moquin-Tandon [2] states that he had never observed the animal creeping or swimming on the surface of the water.

The shell of the animal is fastened to the body by a muscle, which, as already said, passes perpendicularly from the shell and enters the foot obliquely, and with which it coalesces, forming with the foot the sides and floor of the visceral cavity respectively. In the figure (Pl. X, fig. 1) we have a cross-section of the animal about the middle, drawn with a camera lucida, and to which I have added the lines s, which represent a cross-section of the shell. The letters m c represent the musculus cochlearis, which enters the sides of the foot; q m are the transverse fibres.   The longitudinal fibres are not represented, as they are transversely cut and only appear as points.

In the musculus cochlearis of the left side in $A.$ $fluviatilis$ and on the right of $A.$ $lacustris$ a cavity is found in which the heart is situated.   The walls of this cavity form the pericardium.

The gill.—In the space between the foot and the mantle in $A.$ $fluviatilis$ on the left side is found a broad, leaf-like fold of the integument, the gill.   This fold or gill reaches down as far as the lower border of the mantle.   In the figure (Pl. X, fig. 1) the gill (k) is represented on the right side of the section, although really on the left side of the animal, and we must imagine that we are looking at the animal from the front.   The gill is one-third as long as the whole animal and lies in the middle third of the body.   In the living animal it is of a lighter color than the surrounding tissues and the surface of it is smooth.   Although the gill of $A.$ $lacustris$ is on the right side of the animal, its relative position is the same as in $A.$ $fluviatilis$.   The space between the foot and the mantle, into which the gill hangs, may be called the branchial chamber.

I believe that the organ which Moquin-Tandon [3] speaks of as the lobe auriforme is what I prefer to call the gill.   It is physiologically one, as we will presently see.

The whole surface of the gill is covered with ciliated epithelium, and the internal part is formed of cutis, consisting of loose connective-tissue fibres which run in all directions and between

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[1] Manual of Shells, ed. ii, 1840.

[2] Recher. anat. physiol. s. l'Ancyle, etc., p. 35.

[3] Recher. anat. physiol. s. l'Ancyle, etc., p. 12.

which the blood-spaces (lacunæ) are found. A long continuous one runs the whole length of the inferior border of the gill, and is in connection with the mantle-vein. The nuclei of the connective-tissue fibres are very distinct; the rectum passes perpendicularly through the tissues of the middle of the gill, and opens at the anus, situated on the external surface.

Several organs open into the branchial chamber; in the middle of the external surface of the gill, as said, opens the anus. In *A. lacustris*, when the gill is on the right side the rectum and anus also are on that side. Close behind the base of the left tentacle in *A. fluviatilis*, is found the male genital pore or opening, and close behind this the female; as with the anus, these openings are on the right side of *A. lacustris;* in *A. fluviatilis*, on the internal surface of the left mantle, is found the minute opening of the excretory organ, the kidney, which lies embedded in the tissues of the mantle; in *A. lacustris* the kidney is on the right side; thus we see that four organs open into the branchial chamber, the ♂ and ♀ genital openings, the anus, and the kidney.

The alimentary canal.—The mouth, which opens on the inferior surface of the body, is surrounded by three lips; the two anterior lips are placed together so that they form an inverted V (Λ); the open part of the V is closed by the under lip, which is the extreme anterior end of the sole of the foot.

The mouth leads into a small tube, which passes perpendicularly upwards, opening on the floor of the buccal mass (Plate X, fig. 2 *m*). About half-way between the mouth and the buccal mass is situated the horseshoe-shaped jaw, which is placed in the anterior wall of the tube. The jaw consists of a single membrane of conchyolin, upon which are situated numerous little teeth or denticles. Moquin-Tandon says, however, that "*Ancylus* possesses three jaws, disposed as those in *Limnæus*—a transverse one above, and two vertical ones on the sides, * * * the borders of which are formed of a series of little denticles."[1] I do not find this to be exactly the case, but agree with Keferstein, who says: "In *Ancylus* we see, instead of the simple jaw, a large number of long pieces, which are tolerably symmetrically arranged, and encircle

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[1] *L'Ancyle* possède trois mâchoires, disposées comme celles des *Limnées*, une transversale, en haut et deux verticle, sur le côtés * * * celles des bords forment comme une serie de petites denticules : Reche. anat. physiol. s. l'Ancyle, etc., p. 16.

the upper (anterior) side of the cavity of the mouth."[1] These long pieces are the denticles.

The buccal mass, which is of a spheroidal form, lies in the head, between the two tentacles. Immediately over the mouth is found the opening of the œsophagus, and in the middle between these two openings projects the tongue, which is covered by the radula. The odontophore is in *Ancylus* exceptionally long, and reaches from the buccal mass to the middle of the body. The opening of the odontophore lies in the superior part of the buccal mass : the first part of the odontophore itself lies sunken in a groove of the buccal mass, so that seen from the side it appears to spring from the posterior wall.

The diagramatic figure (Pl. X, fig. 2) represents a longitudinal section of the odontophore (*od*), which opens into the spheroidal buccal mass. In the figure the odontophore is relatively much shorter than it is in reality.

After the odontophore leaves the buccal mass it passes backwards, lying directly under the œsophagus and parallel with it; then it passes in *A. fluviatilis* to the right, and in *A. lacustris* to the left side. The œsophagus and odontophore are at the position of insertion in the buccal mass, separated from one another by the commissure of the buccal ganglia. Soon after leaving this commissure the odontophore passes to the side and then upwards and over the œsophagus, so that in the latter part of its course it lies above it.

The alimentary canal has in both species nearly the same form, except that the windings are different. The œsophagus arises in the middle of the superior and anterior angle of the buccal mass, directly over the position where the mouth enters from below (Pl. X, fig. 2 *oe*).

The salivary glands open by a very short duct into the œsophagus, immediately behind the position of its exit from the buccal mass. These glands are two in number, and lie on the side of the œsophagus.

The stomach is of a good size and spheroidal in form, the walls are thick and muscular. It is embedded in the liver, which lies

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[1] Bei *Ancylus* sehen wir an die Stelle der einfachen Kiefers ein grosse Menge kleiner länglicher Stücke treten, welche ziemlich symmetrisch angeordnet, die Oberseite der Mundhöhle umgürten. Bronn's Klass. u. Ord. d. Thierreichs, Bd. iii, 2 Abth., 1862–1866, p. 1190.

beneath, behind and, in *A. fluviatilis*, on the right side; the left
side being covered by the albuminous gland.   In *A. lacustris* the
relation is only reversed, so that the liver lies on the left side of
the stomach and the albuminous gland on the right.

The intestine passes from the stomach at about the middle of
its superior wall and then passes into the liver, forming a loop,
which is clearly visible when the shell is removed in *A. fluviatilis*,
but difficult to be seen in *A. lacustris*.   After a few turns it passes
to the left side of *A. fluviatilis* and to the right in *A. lacustris*,
and proceeds downwards, entering the gill and opening on the
external surface of the same.

I will here call attention to a peculiar ring of long cylindrical
epithelial cells which lies in the walls of the rectum in *A. fluviatilis*.
It is in the middle of that part of the rectum which lies in the gill.
These cells are ciliated, as are indeed the epithelial cells of the
whole intestine.

The physiological significance of the cells forming the ring I
have in no way been able to determine.

In both species the liver is large and fills up the greater part of
the body-cavity.   It consists of a number of follicles; each follicle
is formed of an external tunica propria and an internal layer of
large cells.   These cells secrete the bile, which is led into the
intestine, close behind its exit from the stomach, by means of
three ciliated ducts.

The vascular system.—As the vascular system of *Ancylus*
differs so little from that of mollusca in general, it is not neces-
sary to go into details.   The heart, which is an arterial one, is
formed of two parts, an auricle and a ventricle.   In *A. fluviatilis*
it lies on the left side of the body above the gill and in advance
of the rectum.   The auricle, the smaller of the two parts, is
divided from the ventricle by a contraction, and at this point a
valve is found opening into the ventricle.   From the end of the
ventricle arises the aorta, which soon divides into two branches;
one of these passes to the head (*Arteria cephalica*) and the other
supplies the viscera.   These two branches divide into smaller ones,
and finally open into the body-cavity, where they pour out their
blood.   The blood, which can freely circulate in this cavity, is
collected into the lacunæ of the foot which open in the floor of
the body-cavity.   One of these lacunæ, which can almost receive
the name of vein, passes from the foot into the mantle and becomes

connected with another large lacuna, the mantle-vein, which lies above the tubular part of the kidney. It then sends a branch downwards into the gill, and after passing through this, again becomes joined to the mantle-vein, so that both pass into the auricle together.

The heart lies in a closed sack, the pericardium, on the external walls of which it is fastened (Pl. X, fig. 3 *Ht*). The external wall of the pericardium is only separated from the shell by the mantle, while the other parts lie in contact with the musculus cochlearis. The wall of the pericardium consists of a tunica of connective tissue, in which, here and there, the nuclei can be distinctly seen. The lobe auriforme of Moquin-Tandon[1] is intimately connected with the vascular system, and seems to aërate the blood, and physiologically is a gill.

The generative organs.—*Ancylus*, as is well-known, is hermaphroditic. The hermaphroditic gland or ovitestis, in which sperma as well as ova are formed, lies in the superior and posterior part of the body, immediately below the apex of the shell. In *A. fluviatilis* it lies in the median line, while in *A. lacustris*, where the apex of the shell is wound to the right, the ovitestis also is on the right side of the median.

When the shell is removed from the animal, the ovitestis is easily seen by its having a much lighter color than the surrounding parts.

The larger part of the genitals in *A. fluviatilis* is on the left side of the body, and in *A. lacustris* on the right side. Stephanoff[2] believes that albumen is secreted by the epithelial cells of the ovitestis. I cannot indorse this belief, as I never observed albumen in the ovitestis, and, further, there is a well-developed albumen-secreting gland present which opens into the oviduct. This albuminous gland has been described by C. Vogt[3] and Moquin-Tandon.[4]

I do not consider it necessary to enter into a detailed account of the genitals, as they have been completely described by

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[1] Recher. anat. physiol. s. l'Ancyle, etc., p. 12.

[2] Ueber d. Geschlechtsorgane u. Entwickl. v. Ancylus fluviatilis. Mem. de l'Acad. d. Science d. St. Petersbourg, Tome X, No. 8, 1866, p. 2.

[3] Bemerk. ü. d. Bau d. Ancylus fluv., etc.

[4] Recher. anat. physiol. s. l'Ancyle, etc., p. 540.

Moquin-Tandon[1]; suffice to say that Stephanoff,[2] in his description of these organs, made many blunders, and at the same time did not seem to have known of the existence of Moquin-Tandon's work.

I.—THE FORMATION OF THE RADULA.

The radula is formed in the odontophore. This consists of four parts, which can be best understood by a reference to the figures. Fig. 4 *a* (Pl. X) represents a horizontal section through the posterior portion of the odontophore. Fig. 4 *b* (Pl. X) is a transverse section of the same. Both figures serve to illustrate the four parts making up the odontophore.

First, we have to distinguish the tongue-papilla (Pl. X, fig. 4 *ac*), which fills up the interior of the odontophore; this is surrounded, as is seen in the drawing, by the radula (*r*). External to the radula is the epithelium of the radula. If we make a transverse section through the odontophore (fig. 4 *b*), we find that the radula (*r*) has the form of the letter U, and consequently does not entirely surround the papilla, while the epithelium of the radula (*s*) encircles its external surface. At the open part of the letter U, where the radula is wanting, the epithelium passes gradually into the papilla.

The line *x* in the transverse section (fig. 4 *b*, Pl. X) represents the position of the horizontal section (fig. 4 *a*).

The only part not mentioned now is the fourth and most important of all. I propose to describe it in *Helix aperta*, as the parts in this form are larger and more distinct than in *Ancylus*.

Fig. 5 (Pl. X) represents the posterior part of the odontophore, drawn by a camera lucida. It represents that part of the odontophore which is enclosed by the bracket (*a*) in fig. 4 *a*.

In the drawing we see at that point where the tongue-papilla coalesces with the epithelium of the radula, five large, sharply defined cells (*1, 2, 3, 4* and *5*), which I propose calling the matrix of the radula—thus differing from other writers on the subject, who have not seen these cells, and who call the matrix that part to which I have given the name of tongue-papilla.

Before I pass to the formation of the radula I will first take up the histology of the separate parts of the odontophore in *Helix aperta*.

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[1] Recher. anat. physiol. s. l'Ancyle, etc., p. 337.

[2] U. d. Geschlectsorg. u. d. Entwick. von Anc., etc.

As has already been described by Semper,[1] the tongue-papilla consists of two layers. The internal layer is formed of loose connective tissue, the fibres of which run in every direction, and in which can be distinctly seen the large fusiform nuclei; most of these nuclei are bipolar, although here and there a tripolar one can be seen.

The external layer of the tongue-papilla is made up of cells which possess a large nucleus, and the cell-wall, if seen at all, is very faintly evident; this layer seems more to be a homogeneous mass of protoplasm, in which are embedded large numbers of nuclei; here and there fine lines may be seen, which may be regarded as the cell-walls (Pl. X, fig. 5 m). This layer comes in close contact with the radula and its teeth. The axes of these oval nuclei seem to have a definite direction. In the posterior part they are all directed to the point where the radula begins, while those further forward become perpendicular to the radula itself.

When the object is well stained the difference between these two parts of the tongue-papilla is distinctly seen; the loose internal part being of a light color, while the external part, rich in nuclei, takes a very dark shade.

In *Ancylus* the demarkation between these two parts is not so pronounced as in *Helix*. The peripheral part of the tongue-papilla, rich in nuclei, passes gradually into the loose, pale, internal part (Pl. X, fig. 5 a).

The epithelium of the radula, s (Pl. X, fig. 5), is composed of a single layer of long cylindrical epithelial cells, with well-defined nuclei and distinct cell-walls. These cells are much longer at the posterior part of this layer, i. e., at the point where they lie in contact with the matrix of the radula, than those nearer the mouth. The larger cells rest obliquely on the tunica and parallel to the large cells of the matrix; as they become shorter they become more and more perpendicular, as is seen in the figure (Pl. X, fig. 5 s). The nuclei are small, although with a high power they can be distinctly seen. When thus examined they have the same general appearance of nuclei, and are placed in that part of the cell nearest to the tunica.

Between these long cylindrical cells of the epithelium of the radula and the posterior part of the odontophore are seen five

[1] Zum feinern Bau der Mollusken-Zunge. Zeitschr. f. wiss. Zool., Bd. ix, 1858.

very large cylindrical cells (Pl. X, fig. 5, *1*, *2*, *3*, *4* and *5*), to which I have given the name of matrix. When a horizontal section is examined these cells are very striking and easily distinguished by their having a much lighter color than the surrounding parts; each one of these five cells has a peculiar and characteristic form. The cell marked *1* stands obliquely to the tunica, and that end farthest from the tunica is rounded or dome-shaped; all the other of these five cells, with the exception of *4*, are pointed at the corresponding extremity, and also placed obliquely to the tunica. In *4* this condition is reversed, the pointed extremity being nearest to, but not touching, the tunica. The blunt end of this cell is in contact with the radula, and the point is inserted between cells *3* and *5*.

The protoplasm of these five cells of the matrix is quite clear, taking only a slight reddish tinge with borax (Grenacher's) carmine. There is not the slightest trace of a granulated structure to be found. The nuclei of these cells are very large and oval in form; their size is about twice that of the nuclei that are found in the neighboring tongue-papilla (Pl. X, fig. 5 *m*). The structure of these nuclei differs somewhat among themselves; some contain only one nucleolus, in others it is more or less broken up, and others still have a granular appearance.

The cells *1*, *2* and *3* form the basal membrane (Pl. X, *B. M.*) and cell *4* the bases of the teeth. The convex end of cell *1* secretes a mass of conchyolin, which is the beginning of the basal membrane. The posterior part of this membrane, namely, that part which lies against cell *1* in the figure (fig. 5), has the appearance of a hook, the point of which lies between cells *1* and *3*, just overlapping the tip of the point of *2*. These three cells are those which take part in the formation of the basal membrane of the radula, the cell *3* forming the upper, and cell *1* the lower face of this so-called hook, and cell *2* probably adds a little to the point. This hook-like appearance is only present in longitudinal sections. In reality, naturally, this part of the basal membrane is not a hook, but a sharp edge, which is curled over and fits into a groove formed by two rows of cells; cells like cell *1* (fig. 5) forming the anterior, and cells like cell *2* forming the posterior wall.

The formation of the teeth is carried on by the cell marked *4*. This is triangular in shape with the base abutting the posterior face of the tooth, *d* (Pl. X, fig. 5). I believe that this cell *4* is

formed by division from cell *5*, and dies when the tooth is fully formed, and the remains of this cell are carried forward between the teeth as the radula advances. This can be the only way, for if the cell remained living and continued to secrete conchyolin instead of a series of teeth, we would have simply a solid layer formed on the top of the basal membrane. By a continuous secretion of the cells *1* and *3*, the basal membrane moves or is pushed forward, and thus carries the tooth (*d*) along with it; after this has proceeded for a short distance (viz., the distance of the space between the teeth), a new cell, which has been formed from cell *5*, is ready to commence secreting again, and a new tooth or transverse row of teeth begins to form, and thus the process continues.

The caps of the teeth are shaded darkly in the figure (Pl. X, fig. 5), and are formed after the base of this is completed by cell *4*. The caps are formed by the cells that make up the external layer of the tongue-papilla. If the preparation has been colored with picro- or borax-carmine the basal membrane and bases of the teeth do not color, or only take a slight tinge, while the caps of the teeth are colored darkly. This shows, I should think, that the basal membrane with the bases of the teeth and the caps are of two different formations.

The covering of the odontophore, which may be called the sheath, consists of two layers. The internal, *c′* (Pl. X, fig. 5), which is made up of a simple layer of connective-tissue cells, passes directly into the internal or loose part of the tongue-papilla (*e*), and it seems that this layer is merely a continuation of this part of the papilla. The external layer of the sheath, which covers the whole of the odontophore and is continuous with that which covers the buccal mass, consists of a more compact layer of connective-tissue fibres, in which, as in the internal layer, distinct nuclei may be seen.

In the odontophore the teeth of the radula are directed backward. The radula passes from the posterior part of the odontophore and extends to the opening in the buccal mass, over the tongue, where it makes a bend and returns on the under surface of the tongue; the teeth are placed reverse to those on the upper surface, which are directed backwards, while those on the under surface are directed forwards. In fig. 2 (Pl. X), I have given a diagramatical longitudinal section of the buccal mass and the

odontophore, in order to show the direction of the teeth on the radula (r). The arrow (c) in the same diagram shows the direction in which the radula moves when the animal is rasping the food.

As regards the disappearance of the worn-out and useless teeth, Semper says : " There are only two ways possible, since the view that each tooth continually grows is not to be considered at all. Once we thought, as did Troschel, Claparède and others, that the radula gradually moved forward, and that the forward teeth that were worn out were thus gradually replaced ; or there must be a periodical shedding of the radula. This latter view seems to me the most natural."[1]

Above it was shown that the epithelium of the radula had no connection whatever with the formation of the radula. On the other hand it was observed that the radula as well as the teeth, a, b, c, d, etc. (Pl. X, fig. 5), with the exception of the caps, grew from behind, that is, from the cells of the matrix 1–5 (Pl. X, fig. 5).

From this we see that the radula grows at the posterior end of the odontophore and must gradually be shoved forward, and that the teeth that are used up at the mouth are gradually being replaced from behind. The view of a renewal of the radula by a periodical shedding, as Semper thought most probable, is consequently excluded. In many sagittal sections it is easy to see the anterior part of the radula breaking away at the point, x (Pl. X, fig. 2). At this point separate teeth and parts of the radula could be seen, and they would have been cast out at the mouth.

Trinchese [2] gives in his paper on *Spurilla Neapolitana* a short notice on the development of the radula in this species. He speaks of from five to seven cells which go to form the teeth, and also the cells forming the layer which I have called the epithe-

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[1] "Hier sind nur zwei Fälle möglich, da die Annahme, dass jeder Zahn fortwährend wachse, nicht weiter zu berücksichtigen ist.   Einmal könnte man nun annehmen, dass, wie es auch Troschel, Claparède u. A. thun, die Reibmembran allmählig vorrücke und dadurch sowohl die vordern untauglichen Zähne ersetzt würden, als auch eine Grossenzunahme der Zähne ermöglicht sei, oder man müsste eine von Zeit zu Zeit stattfindende Häutung annehmen ; die letzten Annahme scheint mir die natürlichste." Zum fein. Bau d. Molluskenzunge, p. 277.

[2] Anat. e fisiol. della *Spurilla Neapolitana*.   Estrat. d. Serie III, Tomo IX, d. Mem. dell' Acad. delle Scienze dell' Instituto di Bologna, 2 Febbriao 1878.

lium of the radula. These cells do not form the basal membrane directly. It is formed from the many-layered epithelium of the radula. It is not formed, as one would suppose, by a cuticular secretion of the cells, but at the cost of the cells themselves. The upper layers of the epithelium of the radula coalesce, and thus form the basal membrane. In this manner the epithelium gradually decreases in thickness as it passes forward. Trinchese says, regarding the formation of the radula, that : " The superior part of the body of each shell is divided into many small rods, which are very small at first and which gradually lengthen as they proceed downwards. These small rods are the denticles. The inferior part of the cell, which takes no part in the formation of the tooth, forms with the similar part of the neighboring cell, the tooth-mass or the true body of the tooth. Finally the boundary between the different cells disappears. The nuclei of the tooth-forming cells which remain under the tooth undergo division and give origin to a very compact layer of nuclei, which become more and more pointed as the tooth is shoved forward, are gradually formed in the matrix. When the teeth are so far protruded from the sheath (odontophore), the inferior part of the tooth forms, by means of the layer of nuclei, a very resisting cuticle. This cuticle thickens as the tooth advances, while the nuclei or cell-layer gradually diminish in thickness." [1]

The little rods that he speaks of are not to be found in *Helix aperta*. As the form of the tongue and the radula is as different in *Helix*, and further as the tongue-papilla, in the true sense of

[1] "La parte superiore del corpo di ogni cellula, si divide in tanti piccoli bastoncelli, i quali, molto costi in principio, si allungano man mano manzandosi verso il nucleo il quali viene spinto in basso : questi bastoncelli sono i dentini. La porzione inferiore della cellula che non prende parti alla formazione dei dentini, concorre colla porzione omologa delle cellule vicine a formare il corpo del dente. In fine il limite delle diverse cellule scomparisce ed il dente è così formato. I nuclei delle cellule odontogene rimasti sotto il dente, si segmentano e danno origine ad uno stratodi nuclei molto spesso, il quale si va assottigliando a secunda che ildente viene spinto in avanti dagli altri chi si formans via via nella matrice. Quando i denti sono per uscire dalla guaina, in comincia a formarsi sotte di ossi, per l' atturtà dello strato nucleare, una cuticola molto resistente, la quale li fissa solidamente sul margine della rotella. Questa cuticola, a seconda che il dente si spinge in avanti, divene sempre più spessa, mentre lo strato sottostante si assottiglia e si esaurice.

the term, is wanting in *Spurilla*, it is hardly to be supposed that the formation of the radula is exactly the same.

The cells of the matrix lie, in his figure (Tab. VIII, fig. 2 *b*), behind one another, and only the most anterior one comes in contact with the tooth and takes part in its formation. As is easily seen, these relations are very different from the state of affairs in *Helix*.

Rücker,[1] who does not seem to have known of the paper by Trinchese, calls these teeth the ontoginous teeth. He shows five cells to be present, but not arranged in *Helix pomatia* as I have found to be the case with *H. aperta*. His cell *a* takes the place of my *4* and *5*. Over his cell *d* is formed the future tooth. Then " the part of the cell that lies on cell *d*, the future hook, is raised from its bed, and the tooth passes through the arc of a quadrant in order to assume the normal position."[2]

How or by what means the tooth is raised he does not say. I believe, however, that, as I have shown, the death of cell *4* (Pl. X, fig. 5), after the tooth is formed, is a much more plausible explanation.

II.—OBSERVATIONS ON THE NERVOUS SYSTEM.

The nervous system of *Ancylus fluviatilis* was first described by C. Vogt, in 1841, while that of *A. lacustris*, as far as I know, has never yet been especially described. It is, however, formed on the same plan as that of the former species; the difference in the two being merely one of position. Vogt described the œsophageal ring in the following manner : The œsophageal ring consists of two superior, two lateral, and one inferior ganglia.[3] This description is not correct. The part was better described by Moquin-Tandon[4] in the year 1852.

Moquin-Tandon[4] found that the œsophageal ring consisted of seven ganglia : two superior, which he called the cerebral ganglia

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[1] Ueber die Bildung der Radula bei Helix pomatia. Besond. Abdruck aus d. xxii. Bericht d. Oberh. Ges. f. Natur- und Heilkunde, 1883.

[2] Dann " hebt sich der Zelle *d* aufliegende Theil der Zahner, der zukünftige Haken desselben von seiner Unterlage ab, der Zahn beginnt eine vierteldielung, um allmählig aus der übergekippten in die nomaler Stellung überzugehen." Ueb. d. Bildung d. Radula, etc., p. 217.

[3] " Der Schlundring besteht aus zwei obern, zwei seitlichen und einem untern Knoten." Bemerk. u. d. Bau d. Ancylus, etc., p. 29.

[4] Recher. anat. physiol. s. l'Ancyle, etc., p. 129, *et seq.*

(*g. cèrèbroïdes*), and five inferior (*g. sous-œsophagiens*).   Of these
latter, two lie laterally (*g. supérieurs*), and two lie below the
œsophagus (*g. antero-inferieurs.*)   The fifth is an odd one, and is
placed between the lateral and the inferior ganglion of the left
side, and was called the supplementary ganglion (*g. supplemen-
taire*).

The lateral ganglia are now generally known as the pleural or
visceral ganglia, and the inferior the pedal ganglia.   In *A. lacus-
tris* the supplementary ganglion lies between the visceral and
pedal ganglion of the right side.   The reason of this difference of
position of the supplementary ganglion is probably that in *A.
fluviatilis* the genitals, which are in part supplied by this gan-
glion, lie on the left side; while in the other form, where the
genitals are on the right side, the supplementary ganglion is also
on that side.

Further, Moquin-Tandon [1] speaks of two small ganglia, which
are joined by *connectives* [2] with the cerebral ganglia, and which
he calls the buccal ganglia.

According to Moquin-Tandon, then, the nervous system of
Ancylus consists of nine ganglia.   There exist, however, other
ganglia, which Moquin-Tandon did not find.   Two of these lie in
the tissue of the left mantle of *A. fluviatilis* and in the right of
A. lacustris.   The other two form a pair, and lie in the cephalic
portion, at the base of the tentacles, near the position of the eyes.

First we will consider the two ganglia that are situated in the
substance of the mantle.   They lie in the upper part of the same
between one of the windings of the kidney and the musculus
cochlearis.   These two ganglia are best seen in a horizontal section.
They are very small, so that it would be hardly possible to
demonstrate their existence by dissection.   They are connected
by a bundle of nerve-fibres; besides this, there comes a bundle of
nerve-fibres from the body to the posterior of these two ganglia.
Although I was unable to demonstrate the connection of this

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[1] Recher. anat. physiol. s. l'Ancyle, etc., p. 129, *et seq.*

[2] I use the expression "*connective*," employed by Lacaze-Duthiers (Du
Système Nerveux d. Mollus. gastrop. pulmon. aquat. etc.   Archiv. d.
Zoologie Exp. et Gèn., Tome i, 1872), for those bundles of nerve-fibres
which join ganglia of the same side, in opposition to the term "*commis-
sure,*" which is only employed to denote those nerve-fibres that join ganglia
of opposite sides.

posterior ganglion with the œsophageal ring, I have no doubt of
the existence of such a connection.

We will first consider the anterior and largest of these two
ganglia.   From the form, position and structure I conclude that
this is the so-called ganglion olfactorium.   The existence of this
ganglion was first pointed out by Lacaze-Duthiers [1] in the Pulmo-
nata, but he did not suspect it to be the organ of smell.   He sup-
posed it to be the ganglion that provided for respiration, and at
the same time regulated the large quantity of mucus which is
secreted in the region of the respiratory orifice, the moment the
animal is irritated at this point.   Spengel,[2] in his researches on
this organ in the Prosobranchia, believed it to be the seat of smell,
and gave it the name of the ganglion olfactorium.

In *Ancylus* this ganglion lies on that side of the mantle which
forms the external wall of the branchial chamber, and almost at
the highest point of the chamber, namely, where the gill and
mantle join.

The ganglion consists of cells with larger nuclei which are so
large that they almost fill out the whole cell.   These nuclei take
a dark color when stained in picro-carmine, and are filled with a
large number of fine granules.   No nucleolus was to be seen.   The
whole ganglion is enveloped in a fine tunica, made up of connec-
tive tissue, which is continuous with the tunica that covers the
bundle of nerve-fibres connecting the two ganglia.

The form of this ganglion olfactorium is in general spherical.   At
that point where it comes in contact with the internal surface of
the mantle we find an invagination (Pl. X, fig. 6 *inf.*), so that
the whole ganglion has a cup-like form.   This invagination I call
the infundibulum, because it has the form of a funnel.   The
walls of the infundibulum are lined with cylindrical, cilated
epithelium, which seems to be identical to that which covers the
inner surface of the mantle, save that the cells and cilia of the
infundibulum seem to be a little longer than those of the mantle.

The cells stand perpendicular to the internal surface of the
infundibulum, and are separated from the cells of the ganglia by
an almost imperceptible tunica of very fine connective tissue.   I
was unable to determine positively whether there was direct nervous

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[1] Du Syst. New d. Moll. gast., etc.

[2] Die Geruchsorgane und das Nervensystem der Mollusken.   Zeitschr.
f. wiss. Zoologie, Bd. xxxv, 1881.

connection between the cells of the infundibulum and the ganglion cells, although one undoubtedly exists.

The nerve which connects these two ganglia consists of parallel fibres which are connected with the poles of the ganglion cells. It takes little or no color with picro-carmine, and is quite pale when compared with the surrounding tissues.

The posterior and smaller of these two ganglia I am inclined to believe is the supra-intestinal ganglion, which, according to Spengel,[1] lies in connection with the ganglion olfactorium. It is about one-half the size of this latter ganglion, and lies in the same plane with it, so that a horizontal section through one takes in the other. On one side it lies in contact with the anterior wall of the pericardium ; on the other it touches the internal portion of the same part of the kidney which touches the internal portion of the ganglion olfactorium.

This ganglion receives a branch from the body, which is the one probably connecting it with the œsophageal ring. It sends also a branch posteriorly.

The form and structure of this ganglion are similar to that of the ganglion olfactorium, save that there is no funnel-like invagination. This ganglion has all the points that characterize the supra-intestinal ganglion : first, a branch which connects it with the pleural or visceral ganglion ; secondly, a branch that connects it with the abdominal ganglion, and thirdly, a connection with the ganglion olfactorium.

The tentacular ganglia.—Besides the ganglia already described as belonging to the central nervous system, together with the ganglion olfactorium, there is a pair of ganglia which do not belong to the central nervous system proper, and may be considered as belonging to the peripheral nervous system. These ganglia have already been pointed out by P. B. Sarasin,[2] as existing in the fresh-water Pulmonata. Sarasin agrees with Lacaze-Duthiers,[3] that this pair of ganglia are homologous to those found in the end of the tentacles of *Helix*. They are situated behind the position of the eye, and in close contact with the

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[1] D. Geruchsorg. u. d. Nervensyst. d. Moll., etc.

[2] Drei Sinnesorgane und die Fussdrüse einiger Gastropoden. Arbeit aus dem Zool. Zootom. Instit. zu Würzburg, Bd. vi, 1883.

[3] Die Syst. Nerv. d. Moll. gast., etc.

epidermis. When the eyes are retracted (for they can be retracted in these animals) they lie close to this pair of ganglia.

In *A. fluviatilis* the eyes and ganglia are seen in the same transverse sections (Pl. X, fig. 8). This is not the case in *A. lacustris*, as the ganglia lie a little posterior to the retracted eyes. Each ganglion of this pair lies at the base of a tentacle, and each is ovoid in shape, the longer axis being antero-posteriorly situated. They are covered with a fine tunica of connective tissue. The nerve that supplies them comes from the cerebral ganglia and enters this ganglion on its inner surface. The nerve-cells which make up the ganglia are in every respect similar to those already described for other ganglia.

The tissue of the ganglia is pierced by a bundle of muscular fibres (Pl. X, fig. 7 *rm*), which comes from the buccal mass, pierces each ganglion and is inserted in that part of the epidermis which is covered by the ganglion. This muscle was not observed by Sarasin.[1] When this muscle contracts, the epidermis, together with the ganglion, is drawn inward.

The figures 7 and 8 (Pl. X) represent two transverse sections through the ganglion of the left side of *A. fluviatilis*. In fig. 7 we see this most anterior of the two sections representing the retractor muscle. Fig. 8 shows the relation of the ganglion to the eye. In these two sections we see that the ganglion has a deep groove on its external surface, so that in fig. 7 we have a figure somewhat resembling that of the ganglion olfactorium (Pl. X, fig. 6 *Go*).

This groove, *f* (Pl. X, fig. 7), is caused by the contraction of the retractor muscle. This groove was always present in sections.

In the figure 7, the nerve (*n*) which comes from the cerebral ganglion is seen entering the ganglion in question. At that point where the ganglion comes in contact with the cells of the epidermis (*p*), they seem to be somewhat longer than those surrounding this part. When the surface of this part is viewed from the exterior a pale patch is seen, which is made up of these lengthened epidermal cells. The external surface of these cells is covered with cilia which are a trifle longer than those found on the adjoining epithelium. Sarasin[2] considers this pair of ganglia as a special organ of sense ; I am inclined to believe that we have here an

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[1] Drei Sinnesorgane, etc.

[2] Ueber drei Sinnesorgane, etc.

organ similar to the side line, or side organ, that has been found in the annelides by Eisig[1] and Meyer.[2] The ganglion olfactorium may be one of a pair which would represent another segment, the mate of which has been lost by the disturbance of the bilateral symmetry. This so-called ganglion olfactorium is paired in the lowest Gastropoda, as *Patella*, *Haliotis*, etc., when the bilateral symmetry is not as disturbed as in the higher forms of Gastropoda.

The organ of touch.—Moqu n-Tandon makes the following observation : "*Ancylus* does not possess an especial organ of touch. The foot, which is large, flexible and capable of being exactly applied to solid bodies, and embraces them in part, it is true, receives and transmits tract le impressions, but the animal rarely uses it for this purpose.

" Blainville has proved that the tentacles of the Gastropoda never serve as organs of touch, in spite of their sensibility ; he has merely confirmed the opinion of many earlier naturalists.

" This is not the case with the anterior part of the head, with which the mollusk at times touches different bodies with the appearance of smelling them. I have seen two individuals, which were about to copulate, which had the air of feeling and caressing themselves with the mouth.[3] "

Moquin-Tandon was wrong when he said that no especial organ of touch was present in *Ancylus*, for I have found one without any difficulty. It is probable that Moquin-Tandon was unable to find it, as he did not make any sections of the animal. As would be supposed from the citation, the organ lies in the anterior part of

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[1] Die Seitenorgare und becherförmige Organe der Capitelliden. Mittheil. a. d. Zool. Stat. zu Neapel, Bd. i, 1879.

[2] Zur Anatomie und Histologie von *Polyopthalmus pictus*. Clap., Archiv f. Microscop. Anat., Bd. xxi, 1882.

[3] "L'Ancyle ne possède pas d'organe spécial pour le *toucher active*. Son pied, qui est large, souple et susceptible de s'appliques exactement contre les corps solids, même de les embrasser en partie peut, il est vrai, recevoir et transmettre de impressions tractiles mais l'animal l'emploie rarement à cet usage.

"Blainville à prouvé que les tentacles des gastrop des ne servaient jamais á l'exploration du tact, malgré leur sensibilité ; il n'a fait que confirmer l opinion de plusieurs anciens naturalistes. Il n'est pas de même du chaperon et du moufle, avec lesquel le Mollusque touche quelquefois les divers corps et semble les flaiver j'ai ou deux individus disposé à s'accoupler. qui avaient l'air de se palper et de se carresser avec la bouche." — Recher. anat. physiol. s. l'Ancyle, etc , p. 131.

the upper lip, exactly in that part which, according to Moquin-Tandon, was used for feeling.

The position and presence of this organ can best be demonstrated in longitudinal sections of *A. lacustris* (Pl. X, fig. 9), as in this species it is better developed than in *A. fluviatilis*.

This organ is made up of a certain number of specialized epithelial cells, which are connected with the cerebral ganglion by fine nerves; there are two organs which make a pair, and form a patch on each side of the median line of the upper lip, and each is connected with the cerebral ganglion of its own side.

The cells which make up this organ differ principally from the surrounding epidermal cells in their great size (Pl. X, fig. 9 *b-c*). These specialized cells are not all of the same size, those in the centre of the patch being the longer; and as we approach the periphery, they grow smaller and smaller, until they pass imperceptibly into the surrounding epidermis. This can be seen in the drawing (Pl. X, fig. 9), which represents a longitudinal section through the upper lip of *A. lacustris*.

The external or free surface of these cells is covered with long cilia, which thus differ from the cilia of the surrounding epithelium. The nuclei of these cylindrical cells differ from those found in the neighboring epithelium in form as well as in size. When the object is colored in picro-carmine, the nuclei take a deep color, and stand out sharply from the rest of the cell. Although these nuclei are somewhat different among themselves, they are, in general, fusiform. In this respect they differ from the regular, oval-shaped nuclei of the epidermis. Some of these nuclei appear bent, while others are straight. In fig. 9 (Pl. X) we see that some of the nuclei are pointed only at one end, and others at the other, while only one is pointed at both. In reality, all the nuclei are pointed at both ends, and the reason that they are not so in the drawing is that the nuclei have been cut in two, the knife not happening to pass from one point to the other, but to have taken an oblique course. In consequence of this, some represent the one half, and others the other half, of the nucleus. The bending of the nuclei is due, I believe, to action of the re-agents used in preparing the specimen.

The substance of the nuclei is granular, as the other epidermal nuclei, and I could not find the existence of a nucleolus.

The nerve-endings, which enter the cells of this organ, are the

terminal branches of that nerve which arises in the cerebral
ganglia, and are distributed to this region of the head. They
enter, as near as I could determine, the posterior end of the cell,
and become joined to the posterior end of the nucleus. The
opposite point of the nucleus approaches the free surface of the
cell, and probably is connected in some way with the cilia (Pl. X,
fig. 9 a). In this figure, the muscular and connective-tissue fibres
are intentionally omitted, as it would be difficult to distinguish
the nerve-fibres, were they drawn in.

The other organs of special sense in *Ancylus* are so little different
from those in other Pulmonata, that I do not consider it necessary
to give a description of them here.

III.—The Anatomy of the Excretory Organ.

As yet, no one has completely described the excretory organ of
Ancylus. This organ has only been known in part, and described
under various names. C. Vogt,[1] in the year 1841, spoke of an
organ imbedded in the mantle which he called the " sulphur-yellow
body " (Schwefelgelber Körper), and supposed that the so-called
reticulated portion was the lung.

Moquin-Tandon also considered this organ an organ of respira-
tion, and said : " The breathing organ of *Ancylus* is neither a tube
nor an external gill, it is an internal pouch. I am convinced of
this, after numerous dissections. This pouch is small, oblong,
straight and situated in the left side of the mollusk, toward the
border of the mantle, and in advance of the rectum."[2]

Blainville[3] is of the same opinion, and considers that the orifice
of this respiratory organ is closed by an opercular appendage
(appendice operculaire). This appendage is what I have shown
to be the gill.

Moquin-Tandon adds that the orifice is very small. He further
speaks of a gland that surrounds the heart, concerning which
he says: " The pericardial gland surrounds the heart and the
breathing organ, as is the case with most Gastropoda ; it occupies

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[1] Bemerk. ü. d. Bau d. Ancylus, etc., p. 28.

[2] *L'organe respiratoire* de *l'Ancyle* n'est, ni un tube trachéiform, ni une
branchie externe ; c'est une poche intérieure ; je m'en suis assuré, après
de nombreuses dissections, cette poche est petit, oblongue, etroit, et située
à la partie gauche du Mollusque vers le bord du manteau, en avant du
rectum. Recher. anat. physiol. s. l'Ancyle, etc , p. 123.

[3] Manuel de malacologie et de conchylogie. Paris, 1825, p. 504.

the left and posterior part of the pulmobranchial pouch, and
extends transversely and expands behind the auricle and the
ventricle.   Its color is yellowish, and opens without doubt at the
side of the respiratory orifice."[1]   He says further on: "The peri-
cardial gland produces a very large amount of mucus,   I have
never found calcareous granules in it; these I have only found in
the thick part of the mantle, principally near the margin; they
were very large, a little irregular and transparent."[2]   Although I
have diligently searched for the reticulated part described by C.
Vogt, I have been unable to find it.   It appears to me that he
had reference to what I have called the sacular part of the kidney,
later to be considered, which lies close to the pericardium, the
walls of which have not a reticulated appearance, but are thrown
into longitudinal folds.   C. Vogt regarded this part of the organ
as the lung, while Moquin-Tandon, on the other hand, called it the
pericardial gland.

When the animal is laid upon its back, and the mantle and foot
separated, an S-shaped yellow body is seen through the thin walls
of the mantle.

In *A. fluviatilis* this organ lies in the left, and in *A. lacustris*
in the right lobe of the mantle; this is the organ of excretion, or
the kidney.   Were this organ to be dissected out and measured,
it would be found to be about twice the length of the animal to
which it belonged; thus in an animal measuring 7.4 mm., the
kidney was found to measure 14.4 mm.

In fig. 10 (Pl. X) I have endeavored to give a diagramatical
drawing of the course of the kidney.   To the largest part I have
given the name of the sacular portion; it lies in contact with the

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[1] L'orifice respiratoire est très petit et perce dans un epaississement de la
peu, un peu plus pâle que la reste du tissue * * *.   La glande pericar-
diale est accolée comme dans la plupart des Gastropodes, au cœur et à
l'organe de la respiration; elle occupe les parties glauches et posterieures
de la poche pulmobranche, et s'etend transversalement, en se renflent,
derrière l'oreillette et le ventricle.   Sa coleur est jaunâtre, s'ouvre sans
doute, a côté de l'orifice respiratoire.   Recher. anat. physiol. s. l'Ancyle,
etc., p. 128.

[2] La glande pericardiale produit une assez grande quantité de mucus.
Je n'y ai jamais trouvé de grains calcaires.   J'en ai observé seulment
dans l'epaisseur du manteau particulierment vero sa marge; ils etaient
assez gros, un peu irreguliers et transparents.   Recher. anat. physiol. s.
l'Ancyle, etc., p. 128.

posterior wall of the pericardium. The folds that I have referred
to above are not represented here, as they do not affect the general
form of the organ. At the point b' the sacular portion passes into
the tubular portion. Os represents the opening of the organ
into the branchial chamber. The arrow is given to show the
position of the animal as regards the kidney, the arrow pointing
toward the head. The kidney is drawn as if the observer were
viewing it through the external wall of the branchial chamber.
The little canal (t) which is seen in the anterior part of sacular
portion is the communication between the kidney and the peri-
cardium. The diagram (Pl. X, fig. 10 a) is drawn from a complete
series of transverse sections, by first drawing each section and
then projecting it by measurement to surveyor's paper.

The organ may be divided into two parts, which are in form
entirely different from one another. The first part—that is, that
part which lies next to the pericardium—I call the pericardial or
sacular portion (Pl. X, fig. 10 a); it is the largest and most active
portion of the kidney; it is flattened from the side, so that the
greatest diameter is perpendicular to the animal. The walls, as
above stated, are thrown into longitudinal folds, which are much
deeper at the pericardial end than at the end where this part joins
the others; at this point, in fact, it may be said not to exist, as
they gradually grow fainter until they disappear altogether. The
anterior end of this portion is very broad, and covers nearly the
whole posterior wall of the pericardium. This part, which runs
obliquely backwards and downwards, has an oval form on trans-
verse section which gradually becomes more circular as the folds
disappear and we approach the tubular portion. The length of
this first portion, in an average sized animal, is about 2·8 mm.;[1]
the greatest diameter, 1·0 mm.; and breadth, 0·3 mm.

In the posterior wall of the pericardium is seen a small funnel-
shaped opening (Pl. X, fig. 3 inf), which is lined with long cilia;
this opening leads into a fine tube; this tube lies in contact with
the internal wall of the sacular portion of the kidney for a short
distance, and then opens into it. Here we have, without doubt,
a direct communication between the pericardium and the kidney.

This small tube may be divided into two parts, histologically
different from one another, and the point where this division takes

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[1] All measurements are taken from an animal of average size, which
measured 7·4 mm. in length.

place is where the rectum, which is on its way perpendicularly through this part of the animal to the gill, comes in contact with the tube. The anterior part of this canal I call the prærectal, and the posterior portion the postrectal.

This little canal has nearly the same calibre throughout; the walls of the prærectal part are composed of cylindrical epithelial cells, which lie on a fine tunica propria, and on the free ends of which are found cilia. The cilia are longest at the pericardial opening of this tube. The lumen of the postrectal part is nearly the same as that of the prærectal part; the walls of the former, however, are somewhat thicker.

The internal surface of the excretory organ is also ciliated, and consists of a layer of cylinder epithelium. In the walls are found those concretions so characteristic of the gastropod kidney. These concretions are not found in the walls all over the kidney, but seem confined to a certain part. It is my opinion that the concretions are identical to those small granulations referred to by Moquin-Tandon (see p. 237) in the mucus of this region.

The sacular portion of the kidney does not pass gradually into the tubular portion, but at a sharp angle, as is seen in the diagram (Pl. X, fig. 10), where a little blind sac is formed (Pl. X, fig. 10 z). The diameter of this part of the sacular portion is 0.2 mm.

The second part of the kidney, or the tubular portion, is much longer than the pericardial or sacular portion, but has a much smaller diameter than the latter, and is convoluted. At the beginning it runs parallel with the inferior border of the mantle, and bending at r (Pl. X, fig. 10) it returns on its course; at c' (fig. 10), it makes another bend and passes for a short distance forward again; then forming a slight curve it passes to its most inferior position, and then running parallel with the lower border of the mantle it opens at os, at a position about opposite the posterior part of the gill. In the diagram (fig. 10) I have represented the convolutions as if they were all in one plane; this is, however, not the case, as in a horizontal section we often see two convolutions.

In *A. lacustris* the kidney has essentially the same form, lying in the right mantle, save that the folds of the sacular portion are not so marked.

As to the disposition of the concretion, I can say that they are found in the postrectal and sacular portions, thickly embedded in the walls ; the tubular portion, which may be looked upon as the duct to the glandular or sacular portion, also has them in the first part of its course, as far as *o* (Pl. X, fig. 10); they then become scattered and rarer until we get to *c*, when they have entirely disappeared. The whole interior portion of the organ is ciliated.

EXPLANATION OF PLATE X.

Fig. 1. Transverse section, about the middle of *A. fluviatilis* ; *s*, shell ; *m*, mantle ; *mc*, musculus cochlearis ; *F*, foot ; *qm*, transverse muscular fibres; *L*, liver ; *mg*, stomach ; *E*, albuminous gland ; *D*, intestinal canal ; *K*, gill ; *exo*, excretory organ or kidney.

Fig. 2. Diagram of buccal mass and odontophore ; *m*, mouth ; *b*, curved arrow showing direction the food takes to (*oe*) œsophagus ; *a*, anterior wall ; *c*, arrow showing direction of movement of radula when licking (for *x*, see text) ; *Od*, odontophore ; *r*, radula.

Fig. 3. Part of horizontal section of *A. fluviatilis ; Inf*, infundibulum ; *I* and *ct*, tube connecting kidney (*a*) to pericardium (*P*) ; *Ht*, heart ; *bs*, blood-space ; *m*, mantle ; *R*, rectum ; *mc*, musculus cochlearis ; *alb*, albuminous gland ; *Go*, parts of genital organs.

Fig. 4 *a*. Horizontal section of odontophore of *A. fluviatilis*.

Fig. 4 *b*. Transverse section of same.

Fig. 5. Posterior part of a longitudinal section of odontophore of *Helix aperta*.

For explanation of the letters of the last three figures, see text.

All the figures, with the exception of fig. 2 and fig. 10 have been drawn by means of a camera lucida

Fig. 6. Transverse section of the ganglion olfactorium (*Go*) ; *Inf*, infundibulum ; *m*, mantle ; *d*, kidney ; *Brc*, branchial chamber.

Fig. 7 and 8. Two transverse sections of the tentacular ganglion of left side of *A. fluviatilis* ; *n*, nerve ; *e*, epidermis ; *g*, ganglion ; *p*, enlarged epidermal cells; *f*, groove ; *c*, cutis ; *rm*, retractor muscle ; *au*, eye.

Fig. 9. Longitudinal section of upper lip of *A. lacustris*. For *a*, see text.

Fig. 10. Diagram of kidney of *A. fluviatilis*. For letters, see text.